APPLICATION FOR

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for

# Split Image Stereoscopic System and Method

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# Split Image Stereoscopic System And Method

This application is a continuation-in-part of U.S. Patent Application Ser. No. 09/481,942, filed January 13, 2000, and incorporated herein by reference.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a system and method of stereoscopic imaging, and in particular to a stereoscopic system and method in which the left and right eye images are separately displayed before interlacing so that they can be more easily polarized. This is made possible by using a microprism sheet to interlace the separate oppositely polarized images.

2. Description of Related Art

The present invention provides various improvements on the concept of using microprism sheets to interlace images in a stereoscopic imaging system, as disclosed in copending U.S. Patent Application Ser. No. 09/481,942. The improvements include the identification of additional image sources to which the interlacing arrangements may be applied, modifications of the microprism sheets that are used to interlace the images, and integration of the image interlacing arrangements into stereoscopic video devices that can be used as handheld video game players, visors, and the like.

The invention offers a solution to a number of technical difficulties that have heretofore limited stereoscopic or "3D" devices to unappealing novelty items, implemented in the form of cardboard glasses with blue and red cellophane lenses distributed at fast food restaurants. In particular, the invention makes it possible to use polarizers and polarizing filters rather than color filters to distinguish between left and right eye images by providing a simple way of combining or interlacing the images following polarization, without the need for beam splitters or other sophisticated optical or opto-electronic systems.

The basic principles of stereoscopic imaging are well-known. Human vision is stereoscopic because each eye views the same scene from a different angle. The two separate images are combined by the brain to create a stereoscopic effect. In order to recreate the stereoscopic appearance of a scene on a flat screen, the scene must be captured by two cameras, one representing what a left eye would normally see, and one representing what a right eye would normally see. The left and right eye images are then interlaced so as to originate from the same location. A stereoscopic or three-dimensional image is obtained when each eye sees only the corresponding left and right eye portions of the interlaced image.

There are two ways to optically modify the left and right eye portions of the interlaced images so that the left eye sees only the left eye portion of the interlaced image and the right eye sees only the right eye portion of the interlaced image. One way, illustrated in Fig. 1, is to color the left and right eye portions of the interlaced image 100 and to use color filters 101,102 to ensure that the left and right eyes see only the correspondingly colored portions of the interlaced image. The other way to modify the left and right eye images so that each eye will only see appropriate portions of the interlaced image is to polarize the left and right eye images in opposite

directions, and to use oppositely polarized lenses to view the oppositely polarized portions of the interlaced image.

Polarization has significant advantages over color filtering in that it permits the stereoscopic image to be viewed in natural color without the loss of brightness caused by color filtering. Natural color is in general more pleasing to the viewer, while the increased brightness provided by polarization permits the use of lower intensity image sources such as LCD displays of the type used in portable handheld video game players.

In addition, polarization has the advantage that a person wearing polarized lenses can turn away from the interlaced image and view other objects or persons without having to take off the lenses. Since the polarizers and polarizing lenses are transparent, the stereoscopic effect can be created with what appears to the viewer to be ordinary clear lenses, as opposed to the color lenses used in conventional non-polarizing stereoscopic systems.

Despite the well-known advantages of using polarizing filters to distinguish the left and right eye portions of interlaced stereoscopic images, it is currently impossible to use polarization in connection with conventional cathode ray tube or LCD displays because the light emitting pixels

of the displays cannot be made to emit polarized light. As a result, unlike stereoscopic displays that use color, which can be colorized and interlaced before recording or broadcast, stereoscopic displays that use polarization require that polarization be carried out at the viewing location and, in addition, require that interlacing also be carried out at the viewing location since it is virtually impossible to synchronize or align oppositely polarized sheets with the appropriate portions of an image that has been broadcast or recorded in interlaced form. It is not so much the lack of viable polarizers or polarizing filters that has limited the available of polarizing stereoscopic systems, but rather the lack of a practical image interlacing arrangement for interlacing the images following polarization.

By way of background, examples of image interlacing arrangements using relatively complex or expensive optical devices such as beam splitters are disclosed in U.S. Patent Nos. 5,671,992, 5,993,004, and 5,956,180, while a stereoscopic device utilizing multiple polarizing sheets is disclosed in U.S. Patent No. 5,973,831. In addition, a number of arrangements have been proposed for electronically synchronizing polarizers with temporally interlaced images, *i.e.*, for switching polarization as the left and right eye images are alternately displayed, but

such systems are even more complex than purely optical arrangements.

The present invention, on the other hand, provides a simple and convenient solution to the problem of interlacing images at the viewing location, making possible practical stereoscopic devices that use polarization instead of color filtering, offering a dramatic improvement over the throw-away stereoscopic effects arrangements currently in use, and a practical alternative to the complex optical or opto-electronic systems proposed in previous patents.

## SUMMARY OF THE INVENTION

It is accordingly a first objective of the invention to provide a practical way of optically interlacing separate left eye and right eye portions of a sterescopic image, so that the separate portions of the image can be more conveniently recorded or broadcast, and subsequently polarized, as separate images.

It is a second objective of the invention to provide arrangements for interlacing images in a stereoscopic imaging system that can be used with a variety of different

image sources, including split screens, multiple screens, and combinations of video and static displays or objects.

It is a third objective of the invention to provide a practical arrangement for interlacing oppositely polarized left and right eye images for use in stereoscopic imaging systems and devices.

It is a fourth objective of the invention to provide microprism sheets having improved ability to focus or direct light to a desired location, and which may be used to interlace images.

It is a fifth objective of the invention to provide a projection screen that serves to interlace images.

It is a sixth objective of the invention to provide a handheld device for viewing stereoscopic video images in true color without loss of brightness, and that can be used with an LCD display.

These objectives are achieved, in accordance with the principles of various preferred embodiments of the invention, by providing a stereoscopic imaging system and method in which left and right eye images are separately

transmitted to a display device, polarized following display, and combined following polarization.

Image interlacing is providing by an especially simple and effective arrangement involving a a microprism sheet having one set of surfaces oriented at a first angle corresponding to a position of a first image source, and a second set of surfaces oriented at a second angle corresponding to a position of a second image source so as to interlace the images. By appropriately selecting the position of the images to be interlaced, and therefore the first and second angles, the interlaced image can be made to project into a single plane. If the images are pre-polarized or otherwise differentiated before interlacing, the interlaced images can thus be directly combined to exhibit a three-dimensional stereoscopic effect when viewed directly through corresponding lenses.

The separate images combined or interlaced in the preferred stereoscopic imaging system and method of the invention may be displayed on a split screen, multiple screens arranged horizontally, multiple screens arranged vertically, and may even include images of real objects, as well as images displayed on cathode ray tubes, liquid crystals displays, or any other video or still image displays.

The arrangement of the invention can be used to make an especially simple and yet effective stereoscopic viewing device. Because the invention permits polarization to distinguish left and right eye images, there is no loss of brightness and a relatively dim liquid crystal display can be used as the source of the left and right eye images. The result is a stereoscopic device having a construction that is significantly simpler than the stereoscopic viewing devices or visors of the prior art, which relied on beam splitters or multiple polarizations. Such a stereoscopic device has potential application as a video game player, virtual reality display visor, stand-alone "3D" movie viewer, and so forth.

While especially suitable for use in stereoscopic imaging systems or devices, and in particular those in which the left and right eye portions of a stereoscopic or three-dimensional image are distinguished by opposite polarization, it will be appreciated by those skilled in the art that the image interlacing arrangements of the invention may be used in contexts other than those involving true stereoscopic images, including heads-up displays of various types, closed captioning, or other displays of superimposed images.

In addition to planar microprism sheets disclosed in the parent application, U.S. Patent Application Ser. No. 09/481,942, it is also possible, according to further embodiments of the present invention, to vary the construction of the microprism sheets by varying the shape of individual facets, or by curving the sheets to change the direction of light transmission. Although potentially useful in the context of image interlacing, it will be appreciated by those skilled in the art that this aspect of the invention may be used in a wide variety of microprism applications, including image focusing and projection arrangements in general.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of a prior art stereoscopic imaging arrangement.

Fig. 2 is a schematic diagram illustrating use of a microprism sheet to interlace images according to the principles of a first preferred embodiment of the invention.

Fig. 3 is a schematic diagram showing a handheld stereoscopic device constructed according to the principles of a second preferred embodiment of the invention.

Fig. 4 is a schematic diagram of an image interlacing arrangement according to a third preferred embodiment of the invention.

Fig. 5 is a schematic diagram of an image interlacing arrangement according to a fourth preferred embodiment of the invention.

Fig. 6 is a schematic diagram of an image interlacing arrangement according to a fifth preferred embodiment of the invention.

Figs. 7A-7C are plan views of modifications of the microprism sheets shown in Figs. 2-6.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

As illustrated in Fig. 2, a microprism sheet 1 is arranged such that light from a first image 2 is refracted by surfaces 3 and light from a second image 4 is refracted by surfaces 5 so as to exit the microprism sheet in parallel and thereby form a single interlaced image 6. The angles of surfaces 3 and 5 are selected based on the position of the microprism and on the relative positions of the separate images, which originate in this embodiment from a split screen divided vertically, horizontally, or in

any other desired manner, so that the separate images, which may correspond to the above-described left eye and right eye images, can easily be polarized by polarizing filters or sheets 7,8 positioned between the image source and the microprism sheet before interlacing for viewing by appropriately polarized lenses 9,10 after interlacing.

It will be appreciated that the facets of the microprism sheet 1 illustrated in Fig. 2 are not drawn to scale. The construction of the microprism sheet may be entirely conventional, utilizing the known construction techniques and materials described in copending U.S. Patent Application Ser. No. 09/481,942, or the microprism sheet may be modified to include anti-glare, anti-radiation, or other coatings. In addition, according to the principles described in the copending application, the separate polarizers 7 and 8 may even be replaced by polarizing coatings on individual facets of the microprism sheet 1.

The simple image interlacing arrangement illustrated in Fig. 1 can easily be integrated into stereoscopic effects devices such as the one illustrated in Fig. 3. In this device, the image source is provided by an LCD screen 11, polarization by polarizing sheets 12,13, interlacing by microprism sheet 14, and direction of the appropriate image portions to the left and right eyes of the viewer by

eyepieces 15,16 including polarized filters or lenses 17,18, all of which are contained in a housing 19. In addition, it is within the scope of the invention to provide additional optical components (not shown) for the purpose of focusing or guiding light between the illustrated components.

The stereoscopic effects device of this embodiment of the invention can be used as a portable or handheld video game player, or integrated into a variety of other devices such as arcade games, virtual reality visors, aircraft or military training simulators, and any other devices that currently use flat two-dimensional displays, but which might benefit from the addition of stereoscopic effects.

Instead of a single screen image source as illustrated in Fig. 2, the principles of the invention may be extended to cover images that originate on separate screens 20,21, as illustrated in Fig. 4, or arbitrary image sources 22 other than video screens, including real objects, as illustrated in Fig. 5. In addition, by placing a microprism sheet 23 having appropriately shaped facets in front of a mirror 24, or by adding a reflective coating to the back of the sheet, the image interlacing arrangement can possibly be arranged to form an image interlacing projection screen, as illustrated in Fig. 6.

Finally, as illustrated in Figs. 7A-7C, the microprism sheets used to interlace the images in any of the embodiments of Figs. 2-4 need not be planar microprism sheets with uniform facets. It is also within the scope of the invention to vary the size of the facets so as to focus or project images transmitted thereby, as illustrated in Fig. 7A, to curve the sheets to achieve similar effects, as illustrated in Fig. 7B, or to combine the concepts of varying the size of the facets and curving the sheets, as illustrated in Fig. 7C.

Although potentially useful in connection with image interlacing applications as described herein, the microprism sheet modifications illustrated in Figs. 7A-7C may be used in any context in which microprism sheets are conventionally used, and possibly in additional contexts. For example, if the microprism sheet of Fig. 7B is formed in a parabola shape, the microprism sheet can be used as a convenient focusing lens or collimator.

Having thus described a preferred embodiment of the invention in sufficient detail to enable those skilled in the art to make and use the invention, it will nevertheless be appreciated that numerous variations and modifications of the illustrated embodiment may be made without departing from the spirit of the invention. Accordingly, it is

intended that the invention not be limited by the above description or accompanying drawings, but that it be defined solely in accordance with the appended claims.